

But a careful re-examination of the question shows that, like the beds above described at Richmond, they certainly belong to the Great Oolite, though they were deposited under shallower water conditions than their equivalents at the latter place, and were perhaps, in part at least, of estuarine origin.

The Trias is another formation which has not hitherto been certainly detected under London. It is true that some geologists think that the rocks reached in the Kentish Town and Crossness borings belong to that formation, but this identification is disputed by some very eminent authorities. Although no fossils have been found in the red and variegated strata of the Richmond boring, yet their mineral characters are such as to leave scarcely any room for doubt that they belong to some part of the "Poikilitic" or New Red Sandstone system. They consist of coarse and fine grained sandstones, often exhibiting false-bedding, which alternate with red and variegated clays or "marls." It will be of great interest to geologists if it can be determined upon what member of the Palæozoic rocks these Triassic strata repose.

The result of the deep boring at Richmond is to show that while the water-bearing strata of the Lower Greensand do not extend so far northward as Richmond, other unexpected deposits do exist beneath that town. During portions of the Triassic and Jurassic periods the great Palæozoic ridge, stretching between the Mendips and the Ardennes, was in part or wholly submerged, and thus we find deposits of these ages along its flanks. The relation of the Great Oolite under the central and southern metropolitan district are strikingly similar to those of the Lower Oolite in the Boulonnais. Taking into consideration the proved thickness of the Upper and Middle Oolites in the "Wealden boring" at Battle, we must be prepared to find the Palæozoic axis, with its possible coal-beds, at a considerably greater depth beneath the surface in the southern half of the London Basin than had hitherto been anticipated.

Although no beds of Middle Oolite age have as yet been found under the London Basin, yet, that strata of this period were originally deposited there, we have a very interesting and curious proof. Among the beds of the Lower Greensand of the North Downs, between Sevenoaks and Farnham, we often find deposits consisting of such coarse materials as almost to merit the name of conglomerates. These consist in great part of waterworn fragments of hard and sub-crystalline rocks, evidently derived from the great Palæozoic ridge lying to the north. Mingled with these pebbles are great numbers of excessively eroded but sometimes still recognisable fossils evidently washed out of beds of Lower and Middle Oolite age. The former, as we have just showed, have now been detected under London; but such is not the case with the latter, which may not improbably have been wholly removed by denudation before the deposition of the Cretaceous strata.

In one of the articles referred to at the commencement of this notice, it was pointed out that not only might coal be found at workable depths under London, but that, when discovered, this coal would probably be of the anthracite variety. Now although no beds of coal have hitherto been found in place beneath the metropolis, yet the Richmond boring has yielded striking and un-

mistakable evidence as to the presence and nature of the coal-seams under the London Basin. In several of the deposits pebbles of coal-measure sandstone with fragments of anthracite have been detected. From this interesting fact it may be justly inferred that while the beds in question were being deposited on the flanks of the old Palæozoic ridge, portions of that ridge consisting of Carboniferous strata and containing seams of anthracite rose above the level of the sea and yielded the fragments mentioned. That the source of these fragments was not very distant may be inferred from the brittleness of anthracite, which certainly could not have travelled far. Thus at last the prediction of geologists has been verified, and coal has been found under London, though as yet unfortunately not *in situ*.

JOHN W. JUDD

MENTAL EVOLUTION IN ANIMALS

Mental Evolution in Animals. By G. J. Romanes, M.A., LL.D., F.R.S., &c. With a Posthumous Essay on Instinct, by Charles Darwin. (London: C. Kegan Paul & Co., 1883.)

IN the present volume Mr. Romanes redeems a part of the promise which he gave us in his "Animal Intelligence." He traces in its main outlines the development of mind in the lower animals. The other part of the promise, to follow the course of mental development in man, will be fulfilled in another work. We think it well that the author has thus divided his task. Each division is of sufficient magnitude to require a separate volume; and though as an evolutionist Mr. Romanes would of course maintain the continuity and identity of the process of mental evolution from its first obscure manifestations in the lower grades of animals up to its highest present point of attainment in civilised man, he would probably allow that the two stages of the process, the sub-human and the human, are sufficiently differenced by the difference in the degree of complexity of the factors involved. To this it may be added that the detailed study of each of these two stages of mental life requires a body of knowledge of its own, a special modification of psychological method, and a particular kind of psychological interest.

In the present work the author has to face a much more difficult task than that which he undertook in his earlier volume. This no doubt had its difficulties. For in what we call the "observation" of mind, whether in our fellow-men or in the lower animals, a process of inference is involved; and when the action to be psychologically interpreted is far removed from the ordinary types of human action, this process is one of peculiar difficulty. But in the earlier work inference or interpretation played a subordinate part. Here, however, it becomes the main problem. In order to connect the facts ascertained and to present a systematic view of mental life as a whole, we must have clear notions respecting the nature of mind in general, as well as of its several phases, which we mark off by the names of the faculties perception, imagination, &c. It is not too much to say that in carrying out the task of tracing the evolution of mind in the lower region an inquirer needs to combine the special aptitudes of a naturalist with those of a psychologist.

Readers of the earlier writings of Mr. Romanes are well aware that he possesses a considerable skill in psychological analysis; and the present volume amply justifies the high expectations in this respect which his other works had excited. He shows acuteness and now and again subtlety. But ingenuity is invariably kept in check by that too uncommon quality, sound common sense. He does not strain after originality, but rather takes pleasure in affiliating his views on the doctrines of recognised masters of the science. The reader has throughout the conviction that the writer has a disinterested enthusiasm for his subject, and cares much more for adding to the store of well-ascertained truth than for adding to his own reputation as a contributor to this result. In all this he seems to have caught something of the spirit of his favourite master, Charles Darwin, of whose valuable work in animal psychology the present volume is to so large an extent a continuation.

At the very outset Mr. Romanes has to face a question which makes unusual demands on the inquirer's sobriety of judgment. What are we to include under the head of mind? How far down in the zoological scale can we confidently maintain that mind is to be found? And by what criterion are we to ascertain its presence? The student of psychology need not be reminded that even competent writers have grown confused in seeking to demarcate the area of mental phenomena, whether as presenting themselves in connection with a single organism, or with the sum of organic beings. A trained psychologist like G. H. Lewes used the terms "sensibility" and "sentience" in a way that left his readers perplexed as to whether he was speaking of a psychical phenomenon properly so called, that is, a mode of feeling, or simply of a physiological phenomenon, actions of the nervous system or nervous processes. Mr. Romanes has steered clear of this confusion. He rightly criticises Lewes's use of the term "sensation," and confines it to its proper subjective signification. Mind being thus coextensive with feeling or states of consciousness, the author proceeds to lay down a criterion for ascertaining its presence in any given case. It is as follows:—"Does the organism learn to make new adjustments, or to modify old ones, in accordance with the results of its own individual experience?" Otherwise expressed, it is the manifestation of choice, choice being proved by "the antecedent uncertainty of adjustive action." In laying down this test, however, Mr. Romanes is careful to point out its imperfections. "It is not rigidly exclusive, either, on the one hand, of a possibly mental character in apparently non-mental adjustments, or, conversely, of a possibly non-mental character in apparently mental adjustments." That is to say, it is a rough test sufficient for practical purposes, and eminently in accordance with the dicta of common sense.

After a brief account of the structure and function of nerve-tissue, and of the growing complexity of nerve-structures as evidenced by the double result, compounding of mental elements and compounding of muscular elements, the writer proceeds to discuss what he terms the root-principles of mind. He has already told us that the criterion of mind is choice. He now considers what is involved in the simplest type of choice. Being a mental quality, it must have its physiological correlative.

This the author takes to be what he variously calls "the power of discriminating between stimuli *irrespective of their relative mechanical intensities*," the power of "selective discrimination," of "discriminative excitability," &c. It is illustrated by the capability of a sea-anemone which had been surrounded by a turmoil of water, after a time of expanding its tentacles on contact with a solid body. This implies the discrimination of qualitatively unlike stimuli. Each of the organs of special sense has as its function "the rooting out, selecting, or discriminating the particular kind of stimulation to which its responsive action is appropriate." This power of discrimination is regarded as the root-principle of mind. This doctrine has a certain resemblance to the theory of Mr. Spencer and Dr. Bain, that the feeling of difference is the fundamental mode of consciousness. But the author is very explicit in saying that the discrimination he speaks of is a physiological and not a psychological property. Indeed, he allows that it manifests itself in plants, that is to say, much lower down in the scale of organisms than mind can be supposed to reach. It may, however, occur to the reader that the property is not even peculiar to organic structures. Does not a piano manifest just this selective discrimination (to qualitatively unlike stimuli) when its several strings pick out and resonate to the appropriate vibrations of a composite mass of sound? And is it not easy to conceive an artificial mechanism showing such discrimination in a far higher degree than the lower grades of animals? It may be urged, further, that what choice, as previously defined by Mr. Romanes, requires as its correlative is a germ of *conscious* discrimination. A new adjustive action, not provided for by the inherited nervous structures, seems to involve some vague consciousness of a difference between the new and the old, the exceptional and the usual, circumstances. Mr. Romanes might not improbably meet these difficulties by saying that in calling this physiological discrimination the root-principle of mind he simply means to single out the most important property of nerve-structures, the development of which up to a certain point is an antecedent condition of the appearance of mind or consciousness. But even then it would be hard to see why this was exclusively erected into the root-principle of mind to the disregard of another property, retentiveness or memory, which Hering and others have shown to be a property of all organic structure, and the importance of which, indeed, the author seems to allow later on in his work.

In order to complete the author's account of the physiological conditions of mind it is necessary to add that he supposes consciousness to arise when the time occupied by the nervous process, or the interval between sensory stimulation and muscular action reaches a certain magnitude. Mere complexity of nervous actions does not involve consciousness, as we may see in the case of highly compound reflexes. To use the author's graphic language, consciousness involves as its immediate physiological condition a ganglionic "friction" or "state of turmoil." This increase of time "implies that the nervous mechanism concerned has not been fully habituated to the performance of the response required." As more complex organisms are evolved, and the stimuli playing on them become in consequence more varied, this insufficiency of mechanical arrangements and consequent rise of gang-

lionic friction become more and more marked, and the insufficiency is met by the activity of the higher centres in "focusing many and more or less varied stimuli," which function involves a higher manifestation of the aptitude of discrimination, and as a consequence of this a psychical accompaniment or consciousness.

The author now proceeds to sketch out his general scheme of mental evolution by the aid of a somewhat elaborate diagram. By this last, which is of a tree-like form, we see how out of excitability, the distinguishing property of living matter, there arises, by a double root, contractility, the property of nerve-fibres, and discrimination, the property of nerve-cells, first reflex action, then conscious or voluntary. In branch-like appendages of the stem are represented the successive grades of intellect on the one side, and emotion on the other. To this are added at the sides two finely graduated scales giving the products of emotional and intellectual development. Opposite the numbered divisions of these scales appear the names of those classes of animals, species or larger groups, in which the particular products first distinctly present themselves. Finally the corresponding stages of mental development of the human individual are appended in a parallel scale. It is only fair to Mr. Romanes to say that in thus seeking to mark out by definite stages or levels the progress of mind in the animal series, he is fully aware of the impossibility of assigning hard and fast lines of demarcation. His psychological knowledge tells him that the several faculties, sensation, perception, &c., are not absolutely distinct one from another, but involve common psychical functions. And his clear sense of the limits of our insight into the mind of the lower animals keeps him from dogmatically asserting that a particular faculty or product of mind is not present below a certain zoological level.

Having thus mapped out his ground, Mr. Romanes goes on to investigate its several divisions in detail. The order of treatment is as follows:—(1) sensation, (2) perception, (3) pleasures and pains, memory and association of ideas, (4) perception, (5) imagination, (6) instinct, (7) reason, (8) animal emotions. This does not seem a very good logical arrangement of the subject, or one which grows naturally out of the diagram. It appears, moreover, to make too much of the intellectual side of the animal mind, and too little of the emotional. This strikes one in the cursory treatment of pleasures and pains along with memory, &c., and in the somewhat meagre review of the emotions in the final chapter. The same thing is seen, too, in the elaborate discussion of instinct, in which the highly interesting emotional element in the phenomenon is hardly touched on.

But it is, perhaps, ungracious, in view of the interesting and valuable material with which the author here supplies us, to complain of what he has not given us. To touch on only one or two points of interest, the account of the development of the several varieties of sensation from their simplest rudiments is full and instructive. The fundamental fact in memory, namely, retentiveness, is clearly seized, and it is satisfactorily shown that different grades of memory, *e.g.* mingling of traces of past sensations with present ones, recalling of absent sensations by association, precede the apparently simple but really complex act of perception.

The facts brought forward in proof of the existence of imagination, that is the power of mentally picturing absent objects, even low down in the scale of animals, are interesting and conclusive. The presence in dogs, horses, asses, &c., of what the author calls the third degree of imagination, where the image is not suggested by external objects present at the time, is ingeniously maintained by the facts of dreams, delusions, and evidences of prolonged anticipation, *e.g.* of the stable by the homeward-journeying horse, and recollection, *e.g.* of the lost master or mistress by the pining dog.

The *pièce de résistance* in the volume is, as we might expect, the discussion of the perplexing subject of instinct. To this no fewer than eight chapters are devoted. Here Mr. Romanes shows himself at his very best. We see that he has mastered the wide range of facts involved, and keeps the many varieties of the phenomena steadily in view. We see, too, that he has pondered long and well on his facts, reading what has been said by others on the subject of his meditation. Finally we recognise his thorough sobriety of judgment, freedom from one-sidedness and from everything like speculative extravagance. Mr. Romanes begins by showing that instinct is clearly marked off from reflex action, not merely by the degree of its complexity, as Mr. Spencer says, but by its accompaniment of consciousness. Then he proceeds to illustrate perfect instincts, in which the actions are perfectly adapted to the circumstances of life for the meeting of which the instincts exist, and imperfect instincts, in which the adjustment to the circumstances of the animal's life is less perfect.

This prepares the way for the main problem, the explanation of the origin and development of instinct. There have been two chief theories propounded to meet the case. On the one hand, G. H. Lewes, and also with him apparently Wundt and others, conceive of instinct as a kind of "lapsed intelligence" analogous to the effect of habit as operating during the development of a single human life. Just as we come to do things in a mechanical and semi-conscious way as the result of having frequently done them with full consciousness, so actions of the lower animals carried out with conscious design at first may, as the result of long continuance in succeeding generations and the operation of the principle of heredity, ultimately become instinctive. In opposition to this view, a more humble origin has been assigned to the phenomenon. According to this theory, instinct does not involve intelligence in any stage of the action. Its origin is mechanical. The germ of instinctive action is due to accidental variations which have become fixed and perfected by natural selection. With this view we may take that of Mr. Herbert Spencer, that instincts grow out of reflex actions when these reach a certain degree of complexity, and only involve consciousness in their later stages of development. Mr. Romanes combines these different theories. He allows a certain weight to Mr. Spencer's hypothesis as serving to explain the lowest type of instinctive action occupying the border land between reflex and instinctive actions proper, that is those accompanied by consciousness. But fully developed instincts can only be accounted for by the principle of variation and natural selection, and by that of lapsed

intelligence. In the first place, what the writer calls primary instincts, including those of many low animals and certain instincts of higher animals, *e.g.* incubation, arise by the action of the first cause. This is proved by the fact that purposeless habits, tricks of manner, *e.g.* the trick of barking round a carriage showing itself in certain varieties of dogs, occur and are inherited. In the second place, secondary instincts, including many of those of the higher animals, *e.g.* dread and shunning of man, or other enemies, were originally intelligent actions, and illustrate the principle of habit or lapsed intelligence. This proposition, again, is established by showing first, that "intelligent adjustments when frequently performed become automatic in the individual, and next that they are inherited till they become automatic habits in the race," *e.g.* in the tendency of certain breeds of dogs to "beg."

In combining both these principles in his theory of instinct, Mr. Romanes follows his master, Mr. Darwin, and he has derived much assistance from the valuable essay on instinct by that writer, which was written for the "Origin of Species," but, having been withheld from that publication for want of space, now appears for the first time as an appendix to Mr. Romanes' volume. But the author has elaborated the theory sketched out by Mr. Darwin. More particularly he has illustrated at great length how the two causes may combine. He shows how on the one hand, primary instincts may come to be put to better uses by intelligence, and, on the other hand, secondary instincts may be modified and put to better uses by natural selection. The effects of domestication illustrate most clearly this conjoint action of the two principles. With respect to the comparative importance of the two causes, Mr. Romanes seems inclined to look at natural selection as the chief agency, intelligent adjustment being regarded as an auxiliary agency, the chief function of which is to supply to the controlling principle of natural selection an additional class of variations which are from the first adaptive. Mr. Romanes supports his theory by a cumulative chain of argument of very great strength, and he orders the successive steps of it in such a way as to make the reader feel its full force. His main positions seem to us unassailable. The only point we feel inclined to criticise is the limitation of the action of intelligence in the instincts of animals low down in the scale. The author appears to argue on general grounds that these must to a large extent be due to the working of natural selection. But the facts of intelligent modification of instinctive actions cited by him, *e.g.* in the case of the constructive actions of bees, &c., appear to show that the animals concerned possess a considerable measure of genuine sagacity. And while it is no doubt difficult, as the author remarks (p. 191), to attribute to an animal so low down in the scale as the larva of the caddice fly a power of consciously reasoning, it seems, on the other hand, hard to understand how, by the mere play of natural selection unaided by any rudiment of conscious discrimination and adaptation of means to ends, this little creature could have acquired the habit of either lightening its floating case by attaching a leaf to it or weighting it by attaching a small stone according as it becomes too heavy or too light. But the author shows himself so completely the master of his subject, that the reader feels

disposed to accept his conclusions in the very few instances in which his individual judgment leans the other way.

JAMES SULLY

OUR BOOK SHELF

An Introduction to the Study of Heat. By J. Hamblin Smith, M.A. (London: Rivingtons, 1883.)

THOUGH the author states in the preface that "he has endeavoured in this book to explain the elementary facts connected with the theory of heat so far as a knowledge of them is required by the University of Cambridge in the general examination for the ordinary B.A. degree," it will be found that he has succeeded in producing a book which is not only admirably adapted to help a student who is preparing for this or any other elementary examination, but which, from the simple nature of the language and the clearness of the descriptions, may be read with advantage by those who have no examination to pass, but who may wish to understand something of the science of heat for its own sake.

The text is composed of short numbered paragraphs, in each of which the author deals with one new fact only, a plan eminently adapted to save the student confusion. These paragraphs may be taken as model answers to imaginary examination questions.

Over two hundred questions are given on those parts of the subject, such as expansion, calorimetry, conductivity and hygrometry, which admit of being put in simple numerical form. Many of these are essentially exercises in arithmetic, and must irresistibly remind the reader of the unlikely questions which he used to have to answer at school. In the questions on thermometers, for instance, an observer seems to have noted the sums, differences, products, &c., of the readings of every kind of thermometer in his laboratory, without noticing what those readings were, and then, when too late, to have met with the necessity of finding from his observations the temperatures which the instruments actually indicated. However, though observations of such a kind are rarely made, the exercises which they furnish will of necessity make those who work them out absolutely familiar with the fundamental principles of the subject.

C. V. B.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

The Ear a Barometer

AT a time when I frequently went between Peterborough and London by the Great Northern Railway express trains, I found that the sudden compression of the air produced on entering a tunnel was not only perceptible by the ear, but even unpleasant, and that this unpleasant sensation remained till the open air was reached, when it suddenly ceased. Of course it was natural to suppose that the noise was the primary cause, but I satisfied myself that this had nothing to do with the effect, for on swallowing after entering the tunnel the sensation ceased, but recurred in the opposite sense on leaving the tunnel, when a second operation of swallowing removed it. This showed clearly that what was observed was real.

As far as I remember there was, as measured by the sensation, an increase of pressure, at first sudden, and then gradually rising for a second or two on entering, and a corresponding gradual and sudden decrease on leaving a tunnel.

I did not at the time have the opportunity of taking an aneroid with me to measure the amount of the compression, but intended to try an air thermometer which I thought would be more